Midterm 1

Started: Oct 15 at 11:20pm

Quiz Instructions

Midterm 1 is open book. You are allowed to use any lecture/course notes, homeworks, discussions, or websites (except those for collaborative documents or forums). In addition to this, we will allow the use of a calculator and a Python File or Notebook. You may not access or post on any collaborative documents (e.g. Google Docs) or forums (e.g. Chegg). Collaboration with other students is prohibited.

Assuming you do not have an approved time extension, you will have 1 hour (60 minutes) to complete the Midterm and you may begin the Midterm at any point during the window of 7:10-8:30 pm. However, the Midterm will close at 8:30 pm, meaning that you must start by 7:30 pm to have the full 1 hour. We are not Zoom proctoring.

We will not clarify anything during the exam so please do your best with the information provided. If you have an issue during your exam please email us at eecs16b-fa20@berkeley.edu (mailto:eecs16b-fa20@berkeley.edu) and CC the professors (seth.sanders@berkeley.edu (mailto:seth.sanders@berkeley.edu) and mlustig@eecs.berkeley.edu (mailto:mlustig@eecs.berkeley.edu)).

Good luck!

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<table>
<thead>
<tr>
<th>Question 1</th>
<th>1 pts</th>
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<tbody>
<tr>
<td>Consider the following first-order differential equation</td>
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<td>[ \frac{dx(t)}{dt} = 4x(t) \quad x(0) = 0; ]</td>
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<tr>
<td>What is the solution ( x(t) ) to this differential equation?</td>
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<tr>
<td>[ ] ( e^{4t} )</td>
<td></td>
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<tr>
<td>[ ] ( 1 - e^{4t} )</td>
<td></td>
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<tr>
<td>[ ] ( 0 )</td>
<td></td>
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<tr>
<td>[ ] ( e^{-4t} )</td>
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Question 2

In the circuit shown, we have accidentally introduced a leakage resistance at the output of the inverter. **Use the resistor-switch model** to analyze the operation of this circuit, **ignore all capacitances**.

For the transistors, assume that \( R_{ON,N} = R_{ON,P} = R_{\text{leak}} \) (transistors \( N_1 \) and \( P_1 \) have the same on resistance). The threshold voltages for the NMOS and PMOS transistors are \( V_{tn} = 0.8 \, V \) and \( V_{tp} = -0.6 \, V \) respectively. We are using \( V_{DD} = 1.5 \, V \).

Which of the following statements are **correct** for the operation of the inverter.

- [ Select ] √ **When** \( v_{in} < 0.5 \, V \) **,** transistor \( N_1 \) **is ON** (switch closed).
- [ Select ] √ **When** \( v_{in} > 1 \, V \) **,** transistor \( P_1 \) **is OFF** (switch open).

- [ Select ] √ Pick the correct relationship between \( v_{in} \) and \( v_{out} \).
Question 3

Consider the following circuit with a capacitor that is initially charged with \( v_C(t = 0) = 10V \).

![Circuit Diagram]

Let \( v_s = 20V \), \( C = 10\mu F \), \( R = 20k\Omega \). What is the current passing through the capacitor after 1 second has passed?

\( i_C(t = 1) = \)

- \( 1.993 \cdot 10^6 \text{ A} \)
- \( 9.97 \cdot 10^{-4} \text{ A} \)
- \( 0.135 \text{ A} \)
- \( 19.93 \text{ A} \)
- \( 3.37 \cdot 10^{-6} \text{ A} \)

Question 4

Suppose we have the vector differential equation

\[
\frac{d}{dt} \vec{x}(t) = A\vec{x}(t), \quad \text{where} \quad A = \begin{bmatrix} -4 & 2 \\ -2 & 1 \end{bmatrix}.
\]

Suppose the plot of \( x_1(t) \) is given below with \( \lim_{t \to \infty} x_1(t) = 1 \), what is \( x_2(t) \) when you take the limit as \( t \to \infty \)?
Hint: Think carefully about eigenvalue-eigenvector pairs.

- Not enough information is given to find \( \lim_{t \to \infty} x_2(t) \)
- 1/2
- 1
- 2

Question 5

What is the polar form of the following complex number?

\[ z = -\sqrt{3} - \frac{1}{j} \]

- \( 2e^{\frac{5\pi}{6}} \)
- \( 4e^{\frac{2\pi}{3}} \)
- \( 4e^{\frac{5\pi}{6}} \)
- \( 2e^{\frac{2\pi}{3}} \)
Question 6

Consider the following RLC circuit with unknown values of $R, L, C > 0$ and unknown initial conditions.

Mark all of the following plots of $v_c(t)$ that are possible.

Plot 1: [Select]

Plot 2: [Select]
**Question 7**

What is the phasor for the following time wave form?

\[ i(t) = 2 \sin(\omega t - \frac{\pi}{6}) \]

- \[ 2e^{-j\frac{5\pi}{6}} \]
- \[ 2e^{j\frac{\pi}{6}} \]
- \[ 2e^{j\frac{2\pi}{3}} \]
- \[ 2e^{-j\frac{\pi}{6}} \]
- \[ 2e^{-j\frac{2\pi}{3}} \]

**Question 8**

Consider the below circuit which incorporates a novel circuit device \( X \) whose impedance is of the form \( Z_X = -\frac{1}{\omega^3 X} \):

Where \( v_s(t) = 4 \cos(10t + \frac{\pi}{4}) \), \( R = 10 \mu \Omega \), \( X = 200 \) with units appropriate to fit the above equation. What is the steady state output voltage of \( v_X(t) \)?

- \[ v_X(t) = 2 \cos\left(100t + \frac{\pi}{4}\right) \]
Consider two RLC circuits A and B with sinusoidal inputs that have different $R$, $L$, and $C$ values.

Defining the transfer function $H(\omega) = \frac{V_{\text{out}}}{V_{\text{in}}}$, the magnitude Bode plots of both circuits' transfer functions are shown below.

Mark all of the following statements that are true.
i. Circuit A has a lower quality factor $Q$ than Circuit B. [Select]

ii. Increasing $R_A$ in circuit A will increase its quality factor $Q$. [Select]

iii. Decreasing $R_B$ in circuit B may cause a resonant peak to occur. [Select]

iv. Increasing $C$ in either circuit will decrease its respective quality factor $Q$. [Select]

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**Question 10**

1 pts

Given the following tasks, pick the circuit best suited for each task. Each task will have **exactly one** circuit that matches it the best.

[Diagrams of circuit configurations]
Filtering out noise with frequency larger than 20 kHz.

[ Choose ]

Receiving a transmitted signal in between 2.3GHz and 2.7GHz.

[ Choose ]

Decreasing the amount of bass (lower frequencies) in your sound system.

[ Choose ]

Blocking out the 60 Hz frequency from your wall-power while letting all other frequencies through.

[ Choose ]

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**Question 11**

\[ H(\omega) = 100 \frac{(1+j\frac{\omega}{100})(1+j\omega10)}{1000+j\omega)(1+j\omega)} \]

Below, we have some statements about the magnitude and phase of the transfer function given above. For (i), (ii) and (iii) state if the statements are True/False. For (iv), pick the correct graph.

- [ Select ] As \( \omega \rightarrow 0 \), the magnitude \( |H(\omega)| \rightarrow 100 \).
- [ Select ] As \( \omega \rightarrow \infty \), the magnitude \( |H(\omega)| \rightarrow \infty \).
- [ Select ] At \( \omega = 1 \), \( \angle H(\omega) \approx -\frac{\pi}{4} \).
- [ Select ] Pick the correct graph for the magnitude response \( |H(\omega)| \).
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Graph 1

Graph 2

Graph 3

https://bcourses.berkeley.edu/courses/1499730/quizzes/2329256/take?preview=1